इंटरनेट मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

“जानने का अधिकार, जीने का अधिकार”
Mazdoor Kisan Shakti Sangathan
“The Right to Information, The Right to Live”

“पुराने को छोड नये के तरफ”
Jawaharlal Nehru
“Step Out From the Old to the New”

IS 5469-2 (1973): Code of practice for the use of semiconductor junction devices, Part 2: Diodes [LITD 5: Semiconductor and Other Electronic Components and Devices]

“ज्ञान से एक नये भारत का निर्माण”
Satyanarayan Gangaram Pitroda
“Invent a New India Using Knowledge”

Act Number 22 of 2005
The Indian Parliament
RIGHT TO INFORMATION

Made Available By
Public.Resource.Org

“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”
Bhartṛhari—Nītiśatakam
“Knowledge is such a treasure which cannot be stolen”

BLANK PAGE

BRUTUM FULMEN
IGNORANTIA JURIS NON EXCUSAT
PROTECTED BY COPYRIGHT

IS : 5469 (Part II) - 1973

(Reaffirmed 2006)

Indian Standard

CODE OF PRACTICE FOR THE USE OF SEMICONDUCTOR JUNCTION DEVICES

PART II DIODES

UDC 621·382·23

© Copyright 1974

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110001

~~Price Rs 7·00~~

vised Price [redacted] Gr 4

February 1974

Indian Standard

CODE OF PRACTICE FOR THE USE OF SEMICONDUCTOR JUNCTION DEVICES

PART II DIODES

Semiconductor Devices and Integrated Circuits
Sectional Committee, ETDC 40

Chairman	*Representing*
DR B. H. WADIA	Behram Wadia & Associates, Poona
Members	
DR K. S. BALAIN	Central Electronics Engineering Research Institute (CSIR), Pilani
DR B. R. MARATHE (*Alternate*)	
SHRI S. K. GANGULY	Directorate General of Civil Aviation (Ministry of Tourism & Civil Aviation)
SHRI B. P. GHOSH	National Test House, Calcutta
DR S. K. HAJELA	Indian Telephone Industries Ltd, Bangalore
SHRI K. M. VISWANATHAN (*Alternate*)	
SHRI S. KAPUR	The Radio, Electronics & Television Manufacturers' Association (RETMA)
SHRI S. Y. PHATAK (*Alternate*)	
SHRI G. B. MEEMAMSI	Directorate General of Posts & Telegraphs (Department of Communications), New Delhi
SHRI B. S. MURTHY	Directorate General of Defence Research & Development (Ministry of Defence)
SHRI R. C. PANDEY	Directorate of Technical Development & Production (Air) (Ministry of Defence)
SHRI R. S. YADAV (*Alternate*)	
SHRI D. D. PRADHAN	Semiconductors Ltd, Poona
SHRI W. M. KABIR (*Alternate*)	
SHRI P. S. RAJU	Electronic Corporation of India Ltd (Department of Atomic Energy), Hyderabad
DR RAM PARSHAD	National Physical Laboratory (CSIR), New Delhi
DR Y. R. ANANTH PRASAD (*Alternate*)	

(*Continued on page* 2)

© *Copyright* 1974
INDIAN STANDARDS INSTITUTION
This publication is protected under the *Indian Copyright Act* (XIV of 1957) and reproduction in whole or in part by any means except with written permission of the publisher shall be deemed to be an infringement of copyright under the said Act.

(*Continued from page* 1)

Members	*Representing*
Shri P. K. Rao	Directorate General of Inspection (Ministry of Defence)
Lt Cdr M. K. Sankaran (*Alternate*)	
Shri K. R. Savoor	Bharat Electronics Ltd, Bangalore
Shri G. V. Subramaniam	Continental Devices India Ltd, Faridabad
Shri S. S. Madan (*Alternate*)	
Shri N. Srinivasan, Deputy Director (Elec tech) (*Secretary*)	Director General, ISI (*Ex-officio Member*)

Indian Standard

CODE OF PRACTICE FOR THE USE OF SEMICONDUCTOR JUNCTION DEVICES

PART II DIODES

0. FOREWORD

0.1 This Indian Standard (Part II) was adopted by the Indian Standards Institution on 15 June 1973, after the draft finalized by the Semiconductor Devices and Integrated Circuits Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This Indian Standard (Part II) covers particular considerations applicable to semiconductor diodes.

0.2.1 This standard should be used in conjunction with IS : 5469 (Part I)-1969* which is a necessary adjunct to this standard and which covers general and common requirements applicable to all devices.

0.3 Assistance has been derived from the following while preparing this standard:

BS Doc : 71/20573 Code of practice on the use of semiconductor devices, Part 2 Particular considerations. British Standards Institution.

The use of semiconductor devices. Electronic Valves and Semiconductor Manufacturers' Association, UK.

0.4 This standard is one of a series of Indian Standards relating to semiconductor devices and integrated circuits. A list of standards so far formulated in this series is given on pages 17-18.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

---

*Code of practice for the use of semiconductor junction devices: Part I Applicable to all devices.

†Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard (Part II) gives guidance to all concerned with the design, construction, use or maintenance of equipment using semiconductor diodes so that optimum device performance and life may be secured.

1.1.1 This standard should be used in conjunction with IS : 5469 (Part I)-1969* which is a necessary adjunct to this standard.

2. SIGNAL DIODES

2.1 Certain special considerations that apply to the use of signal diodes are described in this clause and should be read in conjunction with IS:5469 (Part I) - 1969*.

2.1.1 Particular attention should be paid to the possibility of high-energy transients occurring in normally low-power applications and hence diodes with appropriate reverse voltage and forward surge current ratings should be chosen.

2.1.2 Where a signal diode is used in what is essentially a power-rectifier application, some of the considerations of **3** may be applicable.

2.1.3 Junction diodes are inherently more robust than types manufactured by the point contact technique and are generally able to withstand rather higher levels of shock and vibration without deterioration.

2.1.4 The properties of point contact diodes make them generally more satisfactory type for use as RF detectors and mixers. The forward current of point contact diodes is considerably lower than that of junction types at any given voltage, but on the other hand the temperature sensitivity of the characteristics is similar to that of junction diodes.

3. RECTIFIER DIODES

3.1 General — In this clause, certain special considerations that apply to the use of rectifier diodes are described and should be read in conjunction with IS : 5469 (Part I)-1969*.

3.2 Classification of Rectifier Diodes — The broad classification of rectifier diodes can be listed as follows:

a) Rectifier diodes,
b) Avalanche diodes, and
c) Controlled avalanche diodes (*see* Note).

NOTE — These diodes are designed to be able to absorb a specified amount of energy when brought into the reverse breakdown condition. This property gives them some degree of protection against damage due to voltage transients.

---

*Code of practice for the use of semiconductor junction devices: Part I Applicable to all devices.

3.3 Although most of the recommendations in this clause are expressed in terms of the use of diodes as power rectifiers operating from nominally-sinusoidal supplies, many of the considerations are relevant to other applications of similar devices. Where the supply to a rectifier is non-sinusoidal, special care should be taken to ensure that the transient ratings of the device are not exceeded.

3.4 Voltage Ratings

3.4.1 There are four distinct reverse voltage ratings of a diode, as follows (*see* Fig. 1):

a) Crest (peak) working reverse voltage V_{RWM},

b) Repetitive peak reverse voltage (maximum recurrent reverse voltage) V_{RRM},

c) Surge (non-repetitive peak) reverse voltage (peak transient reverse voltage) V_{RSM}, and

d) Continuous (direct) reverse voltage V_R.

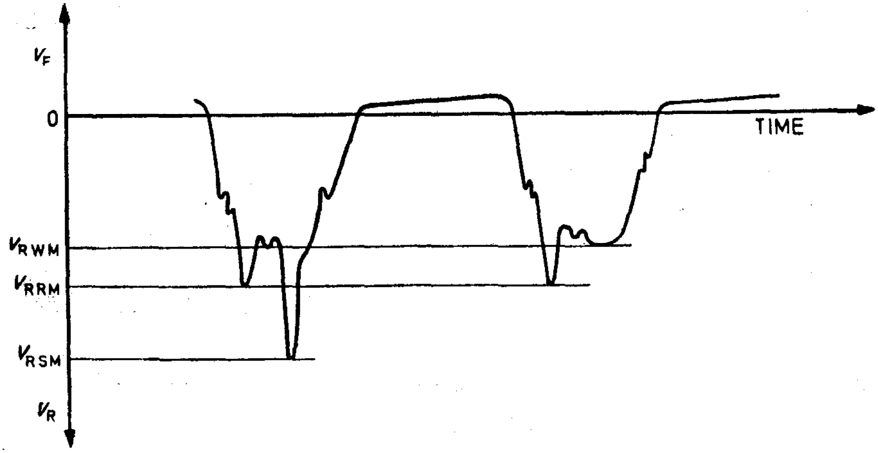

FIG. 1 DIODE VOLTAGE WAVEFORM (GENERAL)

These ratings may depend on temperature and on supply frequency and wave-form. In addition, V_{RSM} is associated with a time limitation.

3.4.2 When using diodes in power-rectifier equipment operating from a general ac supply, voltages in excess of the nominal value may occur across the diodes.

Causes of such transient/excess voltages include:

a) disturbances on the ac supply system,
b) opening of an ac supply circuit to the transformer when the primary current is not zero (this is most likely to be troublesome when the output circuit is lightly loaded),
c) the interruption of fault current by fuses,
d) effect of carrier storage in diodes,
e) opening of a dc circuit breaker on load, and
f) disturbances on the dc circuit-breaker on load.

These transient voltages can be reduced by the resistor-capacitor circuits, non-linear resistors or selenium surge suppressors.

3.4.3 The manufacturer's recommendations should be followed both as to the type of surge suppression and to the margin which it is advisable to allow between the crest working voltage to which the diodes will be subjected under normal conditions and the non-repetitive peak reverse voltage ratio V_{RSM} of the diodes.

3.4.4 Causes of excess voltages that cannot normally be reduced by surge suppression equipment include:

a) supply voltage variation,
b) inherent regulation,
c) no-load voltage rise,
d) regeneration by motors on the dc system, and
e) resonance between circuit inductance and capacitance.

The crest working voltage rating V_{RWM} of the diodes employed shall be high enough to withstand these voltages [*see also* **7.5** of IS:5469 (Part I)-1969*].

3.5 Current Ratings — The following current ratings are applicable:

a) Steady state current ratings,
b) Cyclic overload current ratings,
c) Surge forward current ratings, and
d) Fault or interrupted overload.

Reference may also be made to **6.4** of IS:3700 (Part III)-1973†.

---

*Code of practice for the use of semiconductor junction devices: Part I Applicable to all devices.

†Essential ratings and characteristics of semiconductor devices: Part III Rectifier diodes (*first revision*).

3.5.1 *Steady State Current Ratings* — There are three basic forward current ratings of a diode under steady state conditions as follows:

a) Forward current (whole cycle average) $I_{F(AV)}$ for a 180° conduction angle,

b) Repetitive peak forward current I_{FRM}, and

c) Continuous forward current I_F.

3.5.1.1 These ratings are applicable up to values of ambient or case temperature as shown in the manufacturer's data sheet. For higher values of temperature, the manufacturer's derating curves should be consulted.

NOTE — To determine the case temperature, it is necessary to determine the losses to be dissipated by the diode and the dissipation characteristic of the heat sink.

3.5.1.2 Derating may be necessary for high or low operating frequencies as explained below:

a) At low frequencies because the junction temperature pulsates at the operating frequencies and therefore reaches peak values higher than the average values.

b) At higher frequencies because of the increasing effects of carrier storage.

The ratings also depend on current waveform and conduction angle.

3.5.2 *Cyclic Overload Current Ratings* — This rating is normally specified by means of diagrams as a function of duty cycle for single and multiple overloads. This may be calculated using the maximum junction temperature and the maximum transient thermal impedance for a given duty cycle. Alternatively, this may be calculated from the manufacturer's dissipation characteristics and transient thermal impedance data for specified maximum virtual junction temperature.

3.5.3 *Surge* (*Non-repetitive*) *Forward Current Ratings* — These ratings are specified at the initial conditions corresponding to maximum virtual junction temperature and may also be specified at conditions corresponding to a lower initial virtual junction temperature. These ratings are specified for definite time periods and may be given by means of curves or specified values [Reference may be made to **6.4**(d) of IS:3700 (Part III)-1973*]. Manufacturer's data sheet should be consulted for the specified surge current ratings and care should be taken to see that these values lie well within the specified values under specified conditions.

---

*Essential ratings and characteristics of semiconductor devices: Part III Rectifier diodes (*first revision*).

3.5.3.1 A special case arises in power packs for electronic equipment using a reservoir capacitor. It is usual to limit the peak value of the charging current to this capacitor by the inclusion of an appropriate value of resistor in the circuit. Manufacturer's data will either specify the value of this resistor or the value of the surge (non-repetitive peak) forward current I_{FSM}.

3.5.4 *Fault or Interrupted Overload Current Ratings* — Manufacturer's data provide curves of permissible fault current/time, showing the capability of the device to carry fault current whilst carrying full load current also. Adequate precautions should be taken to see that these ratings are not exceeded.

Where the dc system on short-circuit produces a fault current greatly in excess of the rated load current, the magnitude of the resulting fault current and the time for fault protection equipment to interrupt this current is more likely to determine the current rating required of the diodes than the normal load current.

3.6 Losses — The losses in a diode are composed of three parts, namely:

a) due to carrier storage,
b) due to forward voltage drop, and
c) due to reverse leakage current.

Each of these may contribute significantly to the total diode dissipation.

3.6.1 The losses due to reverse leakage current and forward voltage drop can be calculated from the diode characteristics and the appropriate wave-forms.

3.6.2 The losses due to carrier storage rise with frequency. It is normally negligible at frequencies less than 100 Hz. For operation at higher frequencies the manufacturer should be consulted.

3.6.3 The total diode losses may also be obtained from the manufacturer's power-loss curves.

3.7 Switching Surges — In normal power rectification circuits, the change from forward conduction to reverse does not produce an excessive carrier current. However, special instances can arise where it does, and the peak value of the initial reverse current may be such as to cause failure of the diode. For the protection against such switching surges, suitable delay devices, or protection devices, such as a filter, as specified by the manufacturer should be made use of.

3.8 Overloads

3.8.1 Power rectifiers are usually designed to be capable of delivering certain specified overloads but be protected not only against overloads which are outside the specified limits as regards current and/or time but also against accidental output short circuits.

3.8.1.1 Usually it is the short-circuit current/time requirement which determines the limiting current carrying capacity of the diodes rather than the rated load current and, hence, in large equipments, adequate precaution should be taken to avoid damage due to short-circuit conditions. The manufacturer should be appropriately consulted in such cases.

3.8.1.2 The current under dc fault conditions is determined by the impedance of the circuit which includes that of the supply system, transformer, busbars and connections. Suitable precaution should be taken to reduce the short-circuit current or the fault current.

3.8.2 *Derating* — Overload characteristic curves published by device manufacturers usually show the overload permitted when such an overload is followed by a period at reduced load for a sufficient time to allow the temperature of the diode to fall to its normal full-load value. It is usually assumed that such overloads will occur infrequently in the life of the equipment. Where overloads occur frequently, a suitable derating allowance should be made and the manufacturer should be consulted as to the extent of this derating.

3.8.3 *Fault Protection* — Large overload currents or short-circuit currents of diode shall be interrupted with very little delay if the diodes are not to be destroyed. This is a consequence of their small thermal mass relative to their dissipation. Ordinary fuses are not fast enough to protect diodes against damage by fault currents. Protection against sustained overloads is also not generally economically possible by means of ordinary fuses as the ratio of fusing current to sustained carrying current is too great.

3.8.3.1 For small rectifier equipment of a few amperes capacity, overload and fault protection of the diodes may not be economical. Fuses will, however, be used to protect transformers, chokes and various other parts of the equipment in a normal manner.

3.8.3.2 For medium size rectifier equipment (of a few tens of amperes) the use of a special 'semiconductor fuse' is possible. These fuses are very fast in operation and for protection against fault conditions may interrupt the current before it reaches its 'prospective' value. Such fuses may either be inserted in each limb of the rectifier or between transformer secondary and rectifier.

3.8.3.3 For large rectifier equipment, protection against overloads on ac side is usually provided by ac circuit-breakers controlled by inverse time relays. Protection against load faults or short-circuits may also be provided on dc side by dc circuit-breakers, usually of the 'high speed' type.

Consideration shall also be given to possible overloads caused by the operation of the circuit-breakers themselves as explained below:

a) AC circuit-breakers of the oil immersed type usually interrupt the circuit at a current zero and do not produce appreciable over-voltages. Air blast type ac circuit-breakers may, particularly on light loads 'chop' or interrupt the circuit at an instant of time when the current is not zero. Interruption of the primary magnetizing current of the transformer in this way is a serious source of over-voltage.

b) DC circuit-breakers interrupt the circuit by introducing an arcing voltage in excess of the circuit voltage, this excess 'counter-emf' opposing the inductive voltages in the circuit as the current is caused to decay. Care shall be taken to see that the diodes have a sufficiently high value of non-repetitive peak reverse voltage rating (V_{RSM}) to withstand the portion of the arc voltage of the dc circuit-breaker which is generated by the decay of the fault current in an ac portion of the fault circuits (mainly the transformer leakage reactance).

3.9 Series and Parallel Operation

3.9.0 For general precautions to be observed when using the diodes connected with either in series or in parallel, reference may be made to **7.8** and **9.6** of IS : 5469 (Part I)-1969*. With series or parallel connection of semiconductor rectifier diodes, it is necessary to consider not only the division of voltage or current in steady-state operation (*see* **3.9.1**), but also carrier storage effects during commutation (*see* **3.9.2**).

3.9.1 *Steady-State Operation (Including Overload)*

3.9.1.1 *Series operation* — In order to obtain proper division of voltage in a series connection, one or more of the following methods can be used:

a) Parallel resistive voltage dividers,

b) Parallel capacitive voltage dividers,

c) Factory matched reverse characteristics,

d) Multiple transformer windings (not applicable to single-phase half-wave circuits), and

e) Temperature equalization by mounting on a common heat sink.

The manufacturer should be consulted for detailed recommendations.

---

*Code of practice for the use of semiconductor junction devices: Part I Applicable to all devices.

3.9.1.2 *Parallel operation* — In order to obtain proper division of current in a parallel connection, one or more of the following methods can be used:

a) Factory matched forward characteristics,
b) Addition of resistance or reactance in series with each diode,
c) Balancing transformers or separate transformer windings, and
d) Temperature equalization by mounting on a common heat sink.

It should be remembered that for avalanche rectifier diodes, the spread of avalanche voltage is likely to be such that only one diode of a parallel group will absorb the reverse energy being dissipated. Thus the reverse dissipation capability of the group is no greater than that of an individual diode. The manufacturer should be consulted for detailed information.

3.9.2 *Transient Conditions*

3.9.2.1 *Transient overvoltage due to carrier storage effects* — The diode current during commutation may change rapidly due to carrier storage effects, and associated with circuit inductance, can produce an oscillatory voltage. This transient voltage together with the applied voltage, may often exceed the reverse voltage rating of the diode.

An added shunt capacitance will lengthen the diode recovery time, and reduce the transient overvoltage.

The manufacturer should be consulted for detailed recommendations.

3.9.2.2 *Voltage division of series connected diodes during commutation* — In a series connection of diodes, differences in diode recovery time may produce an unequal voltage division during commutation. Any unbalance may be reduced by a capacitance shunting each diode of the series chain. The capacitors mentioned under **3.9.2.1** may be chosen to meet this purpose.

The manufacturer should be consulted for detailed recommendations.

3.9.3 *Protection Against Diode Failure*

3.9.3.1 *Series operation* — Diodes for series operation are sometimes provided as units complete on heat sinks, with shunt resistors and capacitors and also with diode fuses. If a number of diode units are connected in series for higher voltage, it may be necessary to replace these individual fuses by a single fuse of a voltage rating suitable for the higher voltage. If this is not done there is a risk that one of the series fuses may commence to fuse first and thus insert its arc voltage into the circuit, thereby commencing to reduce the fault current and perhaps prevent the others from fusing. The low arc voltage of the one fusing will then take a relatively long time to reduce the current to extinguishing value and before this occurs the arc inside the fuse may have burnt through an end cap of the fuse and produced a dangerous condition with the evolution of ionized gas.

3.9.3.2 *Parallel operation* — Diodes for parallel operation are sometimes provided as units complete on heat sinks with diode fuses and also with series resistance.

Where fewer than four diodes are used connected in parallel in each limb, it is not usually possible to provide economically continued operation with one failed diode. Arrangements shall be made for a diode failure to ensure complete shut down of the equipment. This can be provided by instantaneous overcurrent relays tripping the main circuit-breaker, or by diode fuses with associated tripping devices, so that the equipment cannot be left on load with one diode failed thus overloading other diodes.

Where four or more diodes are used in parallel in each limb of a rectifier, it is usual to provide one path more than is necessary for the rated current. If one diode in a parallel group suffers reverse failure, it can be isolated from the system by a suitable fuse associated with that diode and the equipment can continue in operation. It is not difficult to achieve discrimination so that only the fuse in series with the failed diode is blown and not the fuses in the other limbs through which the fault current also flows. Discrimination is also possible so that the diode fuses are not blown by through faults (load short-circuits) while the main protection is operating.

4. MICROWAVE DIODES

4.1 In this clause, certain special considerations that apply to the use of microwave diodes are described and should be read in conjunction with IS : 5469 (Part I)-1969*.

4.2 Causes of Damage — Microwave diodes are easily damaged because they have a small contact or junction area (to minimize their capacitance) and because they have a low turnover voltage and high forward conductance. Such damage is called burn-out and can be caused by the following:

a) TR cell leakage in excess of the burn-out rating of mixer diodes;
b) Pulse power absorption in excess of the rating of detector diodes;
c) Stray oscillatory voltages across the diode;
d) Excessive dc voltages;
e) Discharge of static electricity through the diodes; and
f) Stray rf radiations, for example, exposing unshielded microwave diodes to intense rf fields.

4.3 Precautions — Precautions should be taken to reduce the likelihood of burn-out.

---

*Code of practice for the use of semiconductor junction devices: Part I Applicable to all devices.

A few examples of precautions are given below:

a) The diode socket of an equipment may be checked for voltages with the diode out of circuit but the equipment otherwise working.

b) For testing diodes, properly designed test sets in which the applied voltage does not exceed 0·5 volt in either direction may be used.

c) Metal shields should not be removed until the diodes are put into operation.

4.4 Mechanical Compatibility — Microwave diodes are associated with transmission lines or with wave-guides and the diodes are therefore designed to be mechanically compatible with these. The diode mount should be designed to accommodate satisfactorily any diode complying with the relevant outline drawing.

5. PHOTO-SENSITIVE DEVICE

5.1 In this clause, certain special considerations that apply to the use of photo-sensitive device are described and should be read in conjunction with IS:5469 (Part I)-1969*.

5.2 Types of Device — There are three main types of photo-sensitive semiconductor devices, namely, photo-diodes, photo-transistors and photo-conductive cells. These involve a wide range of basic semiconductor materials and are available in many configurations with widely varying limitations which necessitate very careful attention to the manufacturer's data sheet.

5.2.1 *Photo-Diodes* — These rely for their operation upon the inherent photoelectric properties of a junction to which reference is made in **3.2** of IS:5469 (Part I)-1969*. These properties are manifest in both the forward and reverse parts of the characteristic.

5.2.1.1 When a junction is biased in the reverse (high resistance) direction, only the normal leakage current (dark current) flows in the absence of illumination. If the junction is illuminated, its properties are modified and the reverse current increases according to the intensity of illumination.

5.2.1.2 An unbiased junction can be used in the self-generating (photo-voltaic) mode, the power output is then related to the area of the junction, the intensity of illumination, and the load. The most commonly used material is silicon and the open circuit output voltage is of the order of half a volt. There is no output in the absence of incident radiation. Solar cells, which may be used as power sources, are also photo-voltaic cells but the material is not monocrystalline.

---

*Code of practice for the use of semiconductor junction devices: Part I Applicable to all devices.

5.2.1.3 When diodes are used in the self-generating mode as measuring devices the linearity is much dependent upon the resistance of the current-measuring circuits. This is most critical in the case of high level pulsed illumination. In general, the linearity is preserved only when the peak voltage across the actual junction during the pulse is kept well below the saturation open circuit voltage. The permitted terminal voltage for good linearity will be much lower than the actual junction voltage and will depend on the ratio of the load to the internal resistance. Typical figures are 0·2 V maximum at the junction and 0·1 V maximum across the load for say 2 percent linearity.

5.2.2 *Photo-Transistors* — In the photo-transistor the light falling upon the device generates a current which is amplified by transistor action. The device may, therefore, be considered from the photo-sensitive aspect as a diode but from the circuit point of view as a transistor. The precautions arising from both concepts should be observed.

5.2.3 *Photo-Conductive Cells* — These consist essentially of a thin section of semiconductor material whose conductivity changes with the intensity of illumination. The choice of material (cadmium sulphide, indium antimonide) is primarily based upon the required spectral response but involves other considerations, such as the response time-constant. Photo-conductive cells usually have a very thin conducting window as one electrode and, therefore, require the utmost care in handling unless encapsulated or otherwise protected.

5.2.3.1 At very low light levels the performance of most photo-conductive devices is dependent upon the immediate past history of illumination. Some recovery time-constants towards the original dark state are very long (up to an hour or more) and cannot be predicted from abbreviated technical data that quotes the speed of response only at higher light levels (probably in milliseconds). One effect of the change of recovery time-constant with intensity is that in a system where the light is mechanically 'chopped' the linearity will become poor below the intensity of illumination at which the time-constant becomes comparable with the 'chopping' period.

5.3 Spectral Response — The spectral response of the device and the light source should be suitably matched or suitable allowance shall be made. If necessary, the manufacturer should be consulted.

5.4 Stability of Characteristics — All photo-sensitive semiconductor devices are subject to variation of characteristics with temperature and time. Too much reliance should not be placed upon their stability when used in calibrated measuring instruments and facilities for internal standardization are usually desirable. The effects of variations in dark current can be eliminated by 'chopping' the light mechanically and feeding the output of the cell to an ac amplifier. This also eliminated dc amplifier drift. The signal/noise ratio can be much improved by tuning the amplifier to the interruption frequency or by the use of phase-sensitive detection. The effects of changing sensitivity may be eliminated by exposing the device alternatively to the unknown illumination and a known reference illumination.

5.5 Uneven Illumination — Non-linear conditions can easily arise if the illumination is concentrated on a limited area of the device. Sensitivity or stability or both may vary considerably from point to point of the light sensitive area. In general, uneven illumination should be avoided but if it is inevitable, due allowance should be made for the possible effects, including that of local temperature-rise.

5.6 High Intensity Illumination — Fatigue effects (temporary or permanent) may occur when high levels of illumination are maintained for considerable periods.

5.6.1 It may be desirable to protect devices from ultra-violet radiation unless the encapsulation or window provides adequate filtering.

5.6.2 Since the advent of the laser, calibrated photo-devices may be used for the measurement of intense pulsed beams of radiation. Even where the mean energy is small, nanosecond pulses of intense radiation can induce highly disruptive thermomechanical and electrical stresses in materials. Accidental specular reflection may direct a fatal percentage of a laser beam to a photo-device apparently measuring diffused light. (Even 'matt' surfaces at certain angles of incidence or at longer wavelengths can act as specular reflectors.) Damage may not be immediately apparent.

5.7 Sensitivity — In quoting sensitivity the electrical output may be expressed in terms of current, voltage or power, while the incident radiation may be expressed in lumens (total flux) or lux (intensity) or microwatts. Sometimes, quantum efficiency may be preferred to sensitivity. Great care should be taken to interpret the manufacturer's data correctly. Apparent anomalies in performance are often due to misinterpretation of the quoted spectral response or sensitivity or to the use of sources of different spectral composition. Note particularly that whereas the modulation cut-off frequency often refers to the point of half power, the spectral response cut-off may be based on only 1 percent of the peak response (0·1 percent power).

5.8 Dissipation — Incident radiation will raise the temperature of the device. In calculating the energy absorbed, account should be taken of the total incident radiation, particularly that in the far infra-red and not only that part of the spectrum with which the particular optical system is concerned.

5.8.1 For a photo-voltaic cell, the incident radiation is the sole source of heating. All other types of semiconductor photo-devices require an external electrical power source and the electrical dissipation should also be taken into account. The electrical dissipation will vary with the amount of radiation falling on the device within the spectral range to which it responds and will have its highest value for some particular level of radiation. This level will depend on the characteristics of the electrical circuit as well as those of the device.

5.8.2 Care should be taken that accidental exposure to high radiation levels (for example, exposure to direct sunlight) does not cause a total dissipation in excess of the manufacturer's rating.

INDIAN STANDARDS
ON
SEMICONDUCTOR DEVICES

IS :

1885 (Part VII/Sec 1)-1970 Electrotechnical vocabulary: Part VII Semiconductor devices, Section 1 General

1885 (Part VII/Sec 2)-1970 Electrotechnical vocabulary: Part VII Semiconductor devices, Section 2 Diodes

1885 (Part VII/Sec 3)-1970 Electrotechnical vocabulary: Part VII Semiconductor devices, Section 3 Transistors

1885 (Part VII/Sec 4)-1969 Electrotechnical vocabulary: Part VII Semiconductor devices, Section 4 Thyristors

1885 (Part VII/Sec 5)-1971 Electrotechnical vocabulary: Part VII Semiconductor devices, Section 5 Integrated circuits and microelectronics

2032 (Part VIII)-1965 Graphical symbols used in electrotechnology: Part VIII Semiconductor devices

3700 (Part I)-1966 Essential ratings and characteristics of semiconductor devices: Part I General

3700 (Part II)-1972 Essential ratings and characteristics of semiconductor devices: Part II Low power signal diodes

3700 (Part III)-1973 Essential ratings and characteristics of semiconductor devices: Part III Rectifier diodes (*first revision*)

3700 (Part IV)-1968 Essential ratings and characteristics of semiconductor devices: Part IV Low power small signal transistors

3700 (Part V)-1968 Essential ratings and characteristics of semiconductor devices: Part V Power transistors

3700 (Part VI)-1968 Essential ratings and characteristics of semiconductor devices: Part VI Switching transistors

3700 (Part VII)-1970 Essential ratings and characteristics of semiconductor devices: Part VII Reverse blocking triode thyristors

3700 (Part VIII)-1970 Essential ratings and characteristics of semiconductor devices: Part VIII Voltage regulator and voltage reference diodes

3700 (Part IX)-1972 Essential ratings and characteristics of semiconductor devices: Part IX Variable capacitance diodes

3715 (Part I)-1971 Letter symbols for semiconductor devices: Part I General aspects

3715 (Part II)-1971 Letter symbols for semiconductor devices: Part II Diodes

3715 (Part III)-1971 Letter symbols for semiconductor devices: Part III Transistors

3715 (Part IV)-1971 Letter symbols for semiconductor devices: Part IV Thyristors

4400 (Part I)-1967 Methods of measurements on semiconductor devices: Part I General

4400 (Part II)-1967 Methods of measurements on semiconductor devices: Part II Low power signal diodes

4400 (Part III)-1968 Methods of measurements on semiconductor devices: Part III Rectifier diodes

4400 (Part VII)-1971 Methods of measurements on semiconductor devices: Part VII Reverse blocking triode thyristors

4400 (Part VIII)-1970 Methods of measurements on semiconductor devices: Part VIII Voltage regulator and voltage reference diodes

4411-1967 Code of designation of semiconductor devices

5000 Dimensions of semiconductor devices

Note—Standards on dimensions of semiconductor devices are published in loose leaf form (individually priced) and are supplied in an attractive binder (priced separately). So far 26 standards have been published.

5001 (Part I)-1969 Guide for preparation of drawings of semiconductor devices and integrated circuits: Part I Semiconductor devices

5001 (Part II)-1973 Guide for preparation of drawings of semiconductor devices and integrated circuits: Part II Integrated circuits

5469 (Part I)-1969 Code of Practice for the use of semiconductor junction devices: Part I Applicable to all devices

5469 (Part II)-1973 Code of practice for the use of semiconductor junction devices: Part II Diodes

5469 (Part III)-1973 Code of practice for the use of semiconductor junction devices: Part III Thyristors

6553-1971 Environmental requirements for semiconductor devices and integrated circuits

PUBLICATIONS OF INDIAN STANDARDS INSTITUTION

INDIAN STANDARDS

Over 7 500 Indian Standards covering various subjects have been issued so far. Of these, the standards belonging to the Electrotechnical Group fall under the following categories:

- Acoustics and acoustical measurement
- Automobile electrical equipment
- Batteries
- Cinematographic equipment
- Conductors and cables
- Domestic electrical appliances
- Electric welding equipment
- Electrical installations, codes of practice
- Electrical instruments
- Electron tubes and valves
- Electronic components
- Electronic equipments
- Environmental testing procedures
- Fans
- Flameproof electrical equipment
- High voltage techniques
- Illuminating engineering
- Instrument transformers
- Insulating materials
- Insulators and accessories
- Integrating meters
- Lamps and lamp accessories
- Lifts and escalators
- Lightning arresters
- Motors and generators
- Nomenclature and symbols
- Power capacitors
- Power converters
- Relays
- Rotating machinery
- Semiconductor devices
- Switchgear and controlgear
- Transformers and reactors
- Winding wires
- Wiring accessories
- Unclassified

OTHER PUBLICATIONS

ISI Bulletin (Published Every Month)	
Single Copy	Rs 3·00
Annual Subscription	Rs 25·00
Standards : Monthly Additions	
Single Copy	Re 0·30
Annual Subscription	Rs 3·00
Annual Reports (from 1948-49 Onwards)	Rs 2·00 to 5·00
ISI Handbook, 1972	Rs 20·00

INDIAN STANDARDS INSTITUTION

Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110001

Telephone : 27 01 31 (20 lines) **Telegrams : Manaksanstha**

Branch Offices:

	Telephone
'Sadhna', Nurmohamed Shaikh Marg, Khanpur, AHMEDABAD 380001	2 03 91
F Block, Unity Bldg, Narasimharaja Square, BANGALORE 560002	2 76 49
534 Sardar Vallabhbhai Patel Road, BOMBAY 400007	35 69 44
5 Chowringhee Approach, CALCUTTA 700013	23-08 02
Flat No. 1030-31 (First Floor), Sector 22B, CHANDIGARH 160022	2 83 20
5-9-201/2-A (First Floor), Chirag Ali Lane, HYDERABAD 500001	3 44 35
117/418 B Sarvodaya Nagar, KANPUR 208005	82 72
54 General Patters Road, MADRAS 600002	8 72 78
B. C. I. Bldg (Third Floor), Gandhi Maidan East, PATNA 800004	2 56 55

Printed at Britannia Calendar Mfg Co, Calcutta, India